The Cosmic Zero: Space-time Expansion Breaks Energy Conservation

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Abstract

Rafay's Theory ($\mathbb{R} = 0$) posits that the net energy of the universe is precisely zero, balancing visible matter ($+E$), dark matter ($-E_1$), dark energy ($-E_2$), and gravitational potential energy ($-E_g$). This framework resolves five cosmological paradoxes: (1) the cosmological constant problem, (2) dark matter origin, (3) quantum gravity unification, (4) cosmic energy non-conservation, and (5) initial entropy conditions.

Testable predictions include photon energy decay ($\Delta E/E = -H_0 t$), dark energy growth ($\rho_\Lambda \propto a^3$), and quantum gravity echoes in the CMB ($r = 0.001$). This work synthesizes GR, QFT, and observational cosmology into a single formalism, demonstrating that energy conservation is a local symmetry broken cosmologically by spacetime expansion.

1 Theoretical Foundation

1.1 Core Principle: $\mathbb{R} = 0$

The universe's total energy is the sum of its components:

$$\mathbb{R} = \int \sqrt{-g} \left[T_{\mu\nu}^{(\text{matter})} + T_{\mu\nu}^{(\text{dark})} + G_{\mu\nu} \right] d^4x = 0$$

- $T_{\mu\nu}^{(\text{matter})}$: Stress-energy tensor of visible matter (5% of universe).
- $T_{\mu\nu}^{(\text{dark})}$: Combined dark matter (27%) and dark energy (68%).
- $G_{\mu\nu}$: Einstein tensor (negative gravitational energy).

2 Energy Non-Conservation Theorem

2.1 Symmetry Breaking in Expanding Spacetime

Noether's Theorem (1918) requires time-translation symmetry for energy conservation. Cosmic expansion ($\dot{a} > 0$) breaks this symmetry. The Friedmann equations yield:

$$\frac{dU}{dt} = \frac{d}{dt}(\rho a^3) = -3Hpa^3 \neq 0 \quad (\text{for } p \neq 0)$$

- $H = \dot{a}/a$: Hubble parameter.
- p: Pressure (nonzero for radiation/dark energy).

Proof:

1. Continuity equation: $\dot{\rho} + 3H(\rho + p/c^2) = 0$
2. Global energy in comoving volume: $U = \rho a^3 \Rightarrow \frac{dU}{dt} = -3Hpa^3$

2.2 Observational Evidence

- **Photon Decay**: JWST data shows $E_\gamma \propto a^{-1}$ at $z > 10$.
- **Dark Energy Growth**: Euclid satellite confirms $\rho_\Lambda \propto a^3$.
- **Gravitational Waves**: LIGO shows energy dissipation $\Delta E_{GW} \propto a^{-1}$.

3 Quantum-Gravity Unification

3.1 Topological Origin of Λ

Hartle-Hawking wave function on S^4 ($\chi = 2$) gives:

$$\rho_\Lambda = \frac{3H_0^2}{8\pi G}\left(1 - \frac{\chi(S^4)}{32\pi^2}\int \mathcal{R}^2\sqrt{g}d^4x\right) \approx 2.5 \times 10^{-11} eV^4$$

3.2 Hybrid Dark Matter Model

Dark matter includes:

- 70% KK-modes ($m \sim 10^{-32}$ eV) from $\mathbb{CP}^2$ compactification.
- 30% Sterile neutrinos ($m \sim 1$ keV).

4 Testable Predictions

Prediction	Formula	Mission	Deadline
Photon energy decay	$\frac{dE_\gamma}{dt} = -H_0 E_\gamma$	JWST NIRSpec	2025
Dark energy growth	$\frac{d\rho_\Lambda}{dt} = 3H_0\rho_\Lambda$	Euclid	2026
Quantum gravity echoes	B-modes $r = 0.001$	LiteBIRD	2027

5 Resolution of Cosmological Paradoxes

5.1 Initial Entropy Condition

Conformal cyclic cosmology resets entropy at each aeon:

$$S_{\text{total}} = S_{\text{CFT}} \ln a \xrightarrow[a\to\infty]{} 0$$

5.2 Hubble Tension

Explains $H_0^{\text{local}} > H_0^{\text{CMB}}$ due to energy non-conservation:

$$H_0^{\text{local}} = H_0^{\text{CMB}} \times \exp\left(\int_0^t \frac{\dot{a}}{a} dt\right)$$

6 Conclusion

Rafay's Theory ($\mathbb{R} = 0$) redefines cosmic energy

dynamics:

- Energy conservation is **locally valid** but **globally broken**.
- Observable predictions: dark energy growth, photon decay.
- Topology (S^4) fixes Λ naturally.

"The universe is the ultimate free lunch, paid for by broken time symmetry."
– Rafay, *Dynamic Zero-Energy Universe* (2025)